CHAPTER 5. NATIONAL ENERGY AND ECONOMIC IMPACTS

All of the information and results in this Chapter pertain to our analysis for the twelve standards scenarios (1A through 6B) described below. The analysis for the proposed consensus standard (scenarios 7A through 7C) is found in Appendix E. Assumptions for those scenarios that differ from the assumptions described in this chapter are noted in Appendix E.

5.1. METHODOLOGY

Analyzing the national impacts of trial standards for fluorescent ballasts required comparing projected U.S. commercial and industrial lighting energy consumption with and without these standards. In this analysis, we projected interior lighting energy savings as well as net energy impacts of lighting systems on heating, ventilating and air conditioning energy use that would result from trial standards for fluorescent lamp ballasts. Projections of energy consumption in the absence of standards are referred to as *base case projections*. These base case projections were compared to projections of energy consumption if each trial standard scenario were implemented. For each scenario, the difference between the energy consumption of the base case and the standards scenario projection was defined as the energy savings impact of the standard.

The time series of annual energy savings was used along with projected annual electricity prices to calculate fuel cost savings. Lighting equipment expenditures were also projected for the base case as well as for standards. Expenditures and fuel cost savings were used to calculate the national net present value (NPV) of each scenario.

The national energy savings and net present value of the scenarios were calculated using the National Energy Savings (NES) spreadsheet model created by LBNL (NES_v.4). Inputs to the model were: national shipments forecasts, electricity price projections, ballast system characteristics, percentages of different ballast types in fixtures, percentages of ballasts converted to different ballast types under standards, years of standards implementation, and social discount rate.

The NES model calculates the energy savings, fuel cost savings, equipment costs, and net present value for the four major magnetic ballast lamp-ballast combinations: 1F40T12, 2F40T12, 2F96T12, and 2F96T12/HO. In this analysis, a simplifying assumption was made that the 1F40T12, 2F40T12, and 2F96T12 lamp-ballast combinations operated in the commercial sector and that the 2F96T12/HO lamp-ballast combination operated in the industrial sector.

The spreadsheet model is available to interested parties from the U.S. Department of Energy (DOE) website (www.eren.doe.gov/buildings/codes_standards/applbrf/ballast.html). Users may adjust inputs and observe the resulting national energy savings and NPV. In this chapter, we report results using the input assumptions described below.

NES results for projected ballast shipments were also used as inputs to the GRIM model for the manufacturer analysis, described in Chapter 6.

The NES model was used for the Regulatory Impact Analysis, as described in the RIA section.

5.2. DATA

Data on ballast system characteristics (wattages, lifetimes, operating hours, light output, and equipment prices) were identical to those used in the Life-Cycle Cost (LCC) analysis (see Chapters 3 and 4). Electricity price projections for the commercial and industrial sectors were also the same as those used in the LCC analysis and described in Chapter 4. The NES model requires data in addition to those required by the other analyses. These data include: shipments forecasts, percentages of base case ballasts converted to different ballast types in the scenarios, standards implementation dates, social discount rate, and factors for conversion of site energy to source energy.

5.2.1 Shipments

The NES model tracks magnetic ballast shipments from 1997 through 2030. (Savings are calculated beginning with the year the standard is projected to take effect.) It is important to note that the shipments in the NES model are only the magnetic ballasts projected to be used in the base case(s), and those ballasts (electronic or cathode cutout) that replace them in the standards scenarios. The model does *not* track the total ballast market, i.e. the electronic ballasts that would be installed in the base case(s).

Magnetic ballasts shipments were assumed to decline over time under two base case scenarios, as described in section 5.3.1. Both of these scenarios used as their starting point historical ballast shipments data from 1993 to 1997, disaggregated by ballast type, provided to DOE by NEMA for products covered by this analysis. (The Bureau of Census Current Industrial Reports for fluorescent ballasts have slightly different data because they contain ballasts exempted from the standards, including residential low-power factor ballasts, dimming ballasts, and ballasts for several special applications.) The NEMA data presented in Table 5.1 show a modest overall increase in annual total shipments (with a small decrease in 1996); magnetic shipments decrease (with the exception of a small increase in 1997) and magnetic ballasts represent a decreasing percentage over time (with the exception of a small increase in 1996).[1]

Table 5.1 U.S. Fluorescent Ballast Disaggregated Shipments, Covered Products, 1993 - 1997*

Millions of Ballasts

Year	Magnetic F40T12	Electronic F40T12	Total F40T12	Magnetic 2F96T12	Electronic 2F96T12	Total 2F96T12	Magnetic 2F96T12/HO	Electronic 2F96T12/HO	Total 2F96T12/HO
1993	31.0	2.3	33.4	6.9	1.1	8.0	0.4	0.5	0.9
1994	28.1	1.3	29.4	6.9	0.7	7.6	0.4	0.3	0.7
1995	25.6	1.2	26.8	6.4	0.6	7.0	0.4	0.3	0.7
1996	24.7	1.2	25.9	5.9	0.6	6.5	0.3	0.4	0.7
1997	25.4	1.2	26.6	6.0	0.5	6.5	0.3	0.4	0.7

Year	Total Magnetic	T12 Electronic	All T12 Ballasts	T12 + T8 Electronic	Total Ballasts	Percent Magnetic
1993	38.3	3.9	42.3	22.9	61.3	63%
1994	35.4	2.4	37.7	26.0	61.4	58%
1995	32.3	2.1	34.5	33.1	65.4	49%
1996	30.9	2.2	33.1	30.3	61.3	51%
1997	31.7	2.1	33.7	35.0	66.6	48%

* 1997 values are based on six months' of data

Table 5.2 contains data also provided by NEMA, updated through 1998. While these data are more current, they are not disaggregated at the level needed by the NES model. The totals for each year, on which the NES model shipments projection were based, are similar in both data sets, so no appreciable impact on the NES results would be expected from using the more recent data.[2]

Table 5.2 U.S. Fluorescent Ballast Shipments, Covered Products, 1993 - 1998

Year	Magnetic	Electronic	Total	% Magnetic	% Electronic
1993	39.0	22.9	61.9	63%	37%
1994	36.0	26.0	62.0	58%	42%
1995	32.7	33.1	65.8	50%	50%
1996	30.1	29.7	59.8	50%	50%
1997	31.1	35.4	66.5	47%	53%
1998	30.9	37.8	68.7	45%	55%
Total	199.8	185.0	384.7		

Figure 5.1 shows the percentage of the total shipments made up of magnetic and electronic ballasts, based on the NEMA data in Table 5.2. Figure 5.2 shows the annual shipments of magnetic and electronic ballasts from these data by year. It can be seen that magnetic ballast shipments have remained essentially constant over the last three years. Figure 5.3 shows the NEMA shipments data for 1993-1998 and the two shipments forecasts used in the NES analyses. These shipments forecasts are described in section 5.3.1, Base Cases, below.[1]

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[1]A third shipments scenario, Constant Shipments, was used in addition to these two for the consensus standards analysis and is described in Appendix E.

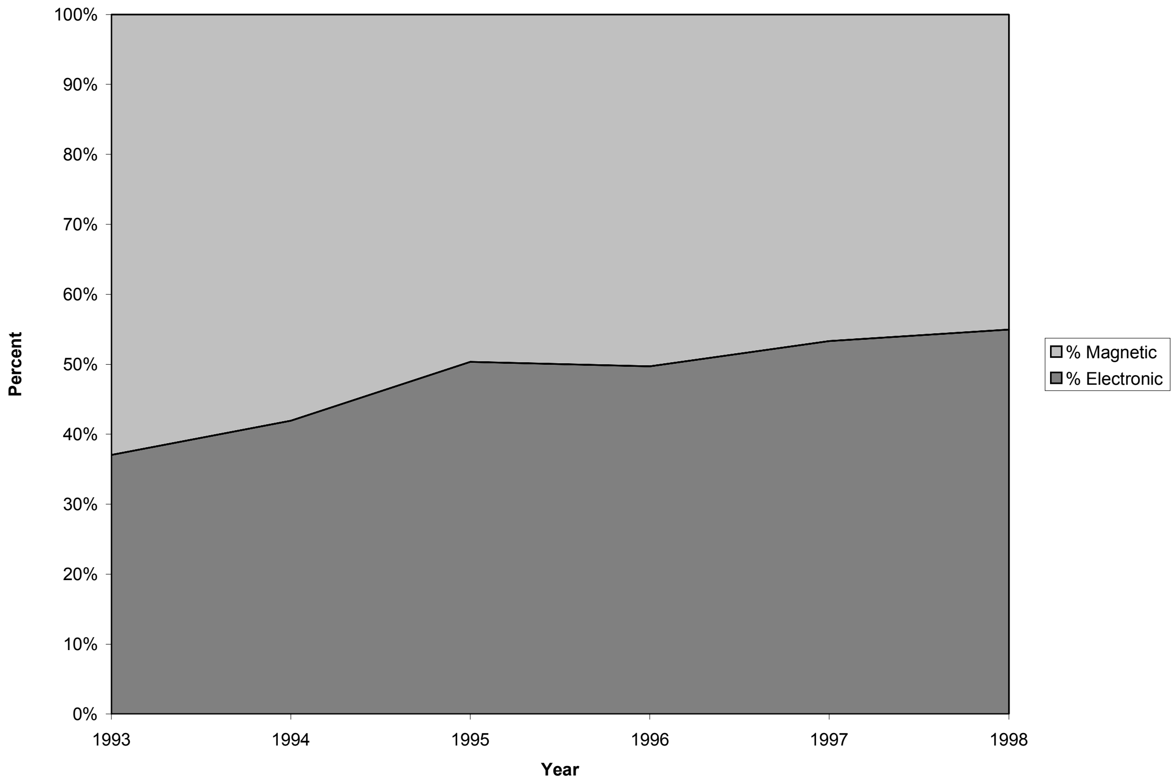

Figure 5.1 Market Share of Magnetic and Electronic Ballasts

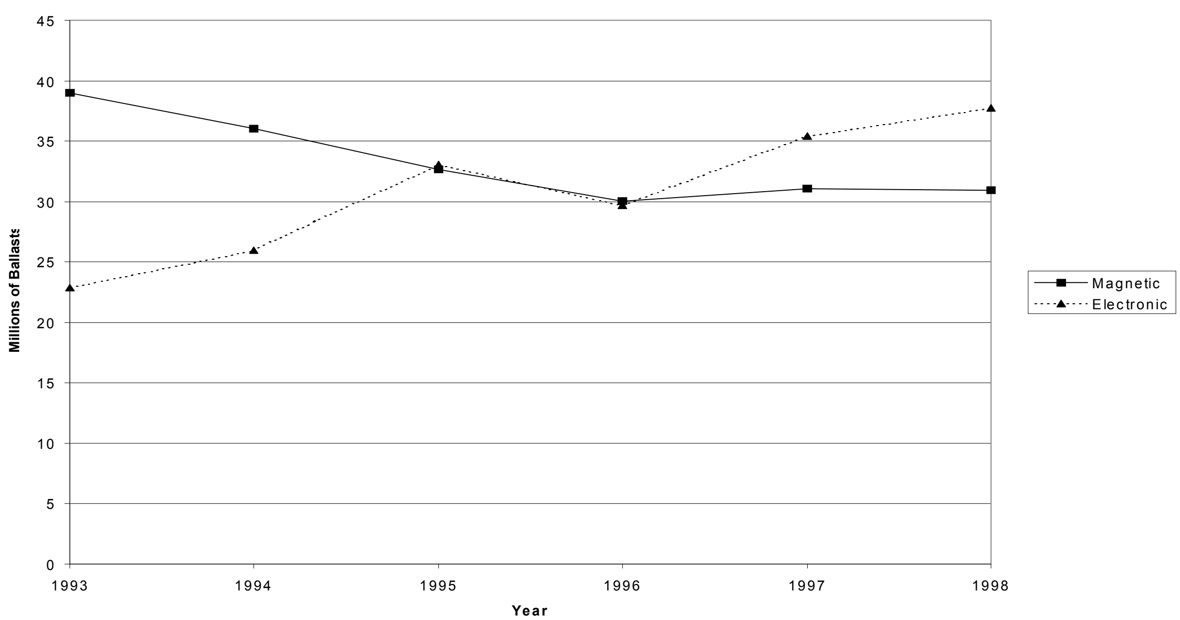

Figure 5.2 Shipments of Magnetic and Electronic Ballasts in Millions.

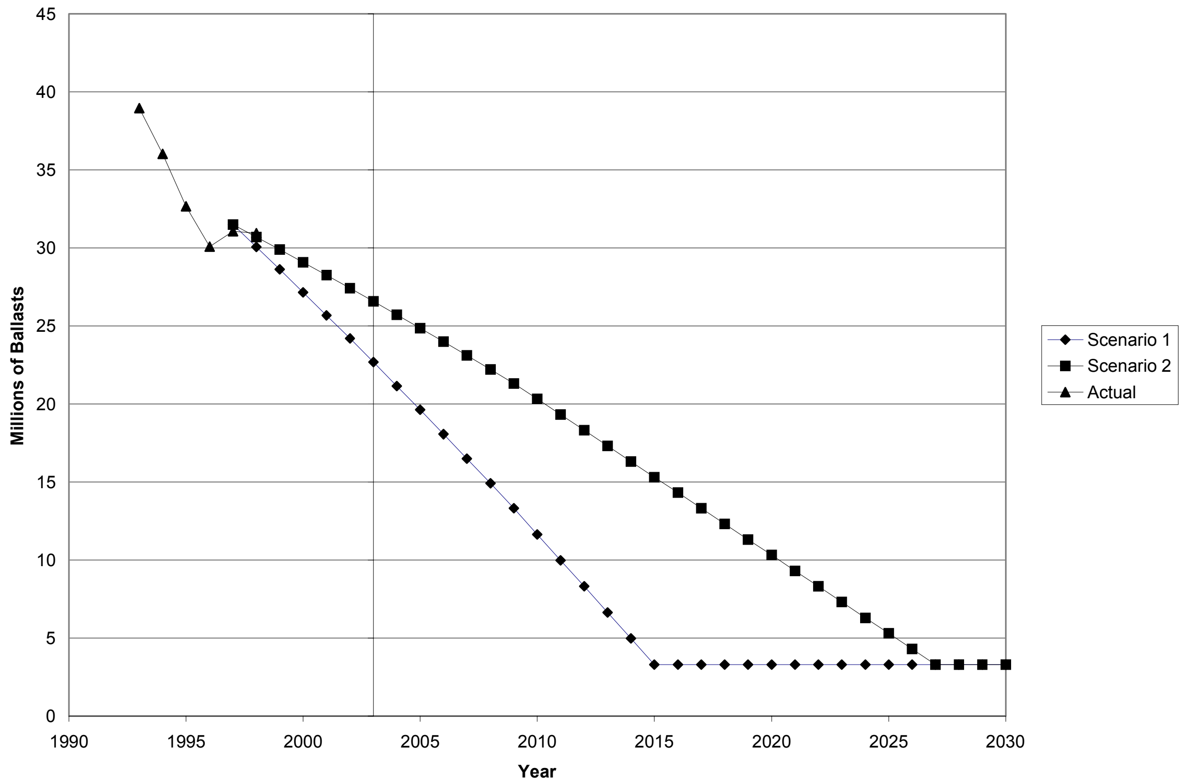

Figure 5.3. MAGNETIC BALLAST SHIPMENT SCENARIOS

The historical shrinking of the market share for magnetic ballasts was projected to continue over time in this analysis. During the first half of the 1990s, this trend was caused in large part by incentive programs, such as utility demand-side management rebates and voluntary federal agency programs, which promoted efficient (primarily electronic) ballasts. As discussed in Appendix B, utility programs have diminished since 1995, but other non-regulatory programs as well as building codes were expected to continue to provide future incentives for installation of efficient ballasts.

The NES model tracks magnetic ballast shipments data for four major lamp-ballast combinations using T12 lamps: one-lamp F40T12, two-lamp F40T12, two-lamp F96T12, and two-lamp F96T12/HO. For the three- and four-lamp T12 lamp-ballast combinations, there are very few magnetic ballast models. T8 magnetic ballasts have a tiny market share.

In the standards scenarios, the T12 magnetic ballasts that would persist in the base case were assumed to be converted to other ballast types as described below. "Converted" meant that the end user, instead of purchasing a new magnetic ballast, purchased and installed another type of ballast because magnetic ballasts were no longer available as the result of efficiency standards. As discussed in section 5.3.1, some scenarios included ballast/lamp system conversions using T8 systems in place of T12 systems.

Energy savings resulted from conversion of magnetic ballasts to more efficient ballasts over time. Total energy savings accrued for ballasts operating from the year in which standards were assumed to take effect, through the year 2030.

For NPV, the electricity cost savings and equipment costs accrued past 2030. The equipment costs of ballasts purchased in the later years of our forecast would be associated with electricity savings beyond 2030. Therefore, electricity cost savings associated with any ballasts purchased before 2030 and occurring in years after 2030 were included in the total for the NPV calculations. For the same reason, the costs of replacement lamps purchased after 2030 to be used in ballasts purchased before 2030 were also counted in the equipment costs. As discussed in Chapter 4, electricity prices were assumed to be constant at the 2020 price after the year 2020.

Two-lamp ballasts are used in two-, three-, and four-lamp fixtures. The percentages of total two-lamp ballast shipments used in each fixture type were estimated as described in Appendix B. Ballast weights for the year 1997 are fixed in the NES model, but ballast weights for the year 2009 can be adjusted by the user. The assumed ballast weights for this analysis are shown in Appendix B.

5.2.2 Market Weights

This analysis contained different scenarios in which the percentages of ballasts converted to the trial standard ballast type (electronic or cathode cutout) varied.

5.2.2.1 Electronic Ballast Trial Standards

Under a trial standard requiring electronic ballasts, some magnetic ballast users would select T12 electronic ballasts while some might select T8 electronic ballasts. This percentage varied in the standards scenarios as described in section 5.3.1.

5.2.2.2 Market Segments

The ballast market has three segments: (1) the new/major renovation market, (2) the replacement market, and (3) the early retrofit market. The new/renovation market consists of luminaires installed in new buildings or buildings where entire lighting systems are replaced; this is also called the original equipment manufacturer (OEM) market. The replacement market consists of ballasts replaced at the end of life (typically spot-replaced at failure). Some of the trial standards scenarios analyzed had different standards implementation dates for the new/renovation and the replacement markets (see section 5.2.3) as well as different assumptions for the percentage of magnetic ballasts converted to electronic T12 and electronic T8 ballasts for these two markets.

The early retrofit market, which consists of ballasts replaced with more efficient models before they fail, was considered to be covered in the base case scenarios with their decreasing magnetic ballast shipments. This market is already installing efficient ballasts and would be little affected by the trial standards.

5.2.2.3 Cathode Cutout Trial Standards

Under a trial standard requiring cathode cutout ballasts, magnetic ballast users could select cathode cutout ballasts, or they could purchase electronic ballasts, which would also comply with the standard. In the scenarios analyzed, the percentage of magnetic ballasts converted to cathode cutout ballasts varied, as described below. In the scenario with some electronic ballasts, a certain percentage was assumed to be T12 ballasts and remainder to be T8 ballasts.

5.2.3 Year of Standards

The effective date for trial standards was assumed to be 2003. For some electronic ballast scenarios, the effective date applied to the new/renovation market, with a delay period of two or five years for the replacement market.

5.2.4 Social Discount Rate

The DOE selected a 7 percent social discount rate for the national NPV analysis.

5.2.5 Electricity Conversion Rates

The NES model calculates site energy in terawatt-hours and converts the results to source energy in quads using values from the Annual Energy Outlook 1999 (AEO 99). The conversion factor from quads to exajoules is:

1 quadrillion Btus (quad) = 1.055 exajoules (1 Btu = 1.055 joules)

AEO 99, Table A5 (Commercial Sector Key Indicators and Consumption), lists delivered electricity energy and electricity-related losses in site quads for the years 1996 and 1997, as well as for the years 2000 to 2020 in five year intervals; EIA provided the data for the intermediate years. The conversion factor for source energy is calculated using the formula:

$$SourceEnergy(MMBtu) = kWh * 1000 * \frac{3412\,Btu}{kWh} * \frac{SiteEnergy(Quads) + Losses(Quads)}{SiteEnergy(Quads)}$$

Losses are in electricity generation, transmission, and distribution. For 2020 to 2030, the conversion rates are estimated using the rate of change between 2010 and 2020.

Table 5.3 shows the site- to source-energy conversion rates for the analysis period.

Table 5.3 Site-to-Source Energy Conversion Factors

Year	Conversion Factor MMBtu/KWh		Year	Conversion Factor MMBtu/KWh		Year	Conversion Factor MMBtu/KWh
2001	0.010871		2011	0.010145		2021	0.009638
2002	0.010780		2012	0.010072		2022	0.009587
2003	0.010691		2013	0.010022		2023	0.009538
2004	0.010552		2014	0.009946		2024	0.009488
2005	0.010460		2015	0.009871		2025	0.009439
2006	0.010397		2016	0.009818		2026	0.009390
2007	0.010335		2017	0.009782		2027	0.009341
2008	0.010299		2018	0.009750		2028	0.009292
2009	0.010270		2019	0.009713		2029	0.009244
2010	0.010206		2020	0.009688		2030	0.009196

5.2.6 Lighting/HVAC Interactions

When lighting energy consumption is reduced through installation of more efficient equipment, there is a secondary impact on cooling and heating energy consumed by the building heating, ventilating, and air conditioning (HVAC) systems. Because less heat is given off by the more efficient lighting systems, less cooling is needed in some buildings or spaces while more heating is needed in other buildings or spaces. The annual HVAC impact varies by climate zone and building type. As explained in Appendix B, this analysis used a national average for HVAC impacts that included a cooling decrease for some climates and building types and a heating increase for others. This *net* national average impact was estimated to be an additional 6.25 percent of the total national lighting energy savings from each scenario. HVAC savings were not included in the total energy cost benefit and therefore were not in the NPV calculation.

5.3 STANDARDS SCENARIO ANALYSIS

DOE analyzed the impact of two trial standard levels, one for electronic ballasts and the other for cathode cutout ballasts. We considered the following scenarios for electronic ballast standards: end users of magnetic ballast T12 systems choose (1) 100 percent T12 electronic ballasts or (2) 95 percent T8 and 5 percent T12 electronic ballasts, which is consistent with current market shares. We also considered two other scenarios. Scenario (3) assumed that the standard requires than the new/renovation market segment converts all ballasts to electronic, with 100 percent becoming T8 ballasts, starting on the effective date for efficiency standards. This segment was assumed to make up 70 percent of the total ballast market based on current market data supplied by NEMA for magnetic ballasts sold to OEMs[3]. The remaining 30 percent, the replacement market, delayed for five years and then converted to electronic ballasts; 5 percent became T12 ballasts and 95 percent became T8 ballasts. Scenario (4) was identical to (3) except the delay in conversion for the replacement market was two years. We considered the following scenarios for cathode cutout ballasts: end users choose (1) 100 percent cathode cutout ballasts and (2) 30 percent cathode cutout and 70 percent electronic ballasts. See sections 5.3.3 and 5.3.4 and Table 5.4 for further explanation of the Scenarios.

Two base case forecasts of shipments of magnetic ballasts without standards were used as a reference case to which the standards scenarios were compared. Therefore, there were a total of eight possible electronic ballast standards scenarios and four cathode-cutout standards scenarios, as described below.

5.3.1 Base Cases

5.3.1.1 Decreasing Shipments to 2015

In this base case, ballast shipments from 1997 through 2030 were assumed to decrease at the rate at which most magnetic ballast shipments declined from 1993 through 1997. This rate was based on a linear regression through the historical shipments data for those years (shown in Table 5.1). This rate represented a 5 percent annual decrease from 1997 shipments levels.

To account for the fact that without regulatory action some magnetic ballasts would continue to be used, shipments decreased to a base level (rather than zero) in 2015 and remained at this level through 2030. The base level was calculated as 10 percent of the magnetic ballast shipments in 1997 for each ballast lamp-ballast combination.

5.3.1.2 Decreasing Shipments to 2027

In this base case, shipments from 1997 through 2030 were assumed to decrease at a slower rate than in the 2015 case, reaching the base level by 2027. This rate represented a 3 percent annual decrease from 1997 shipments levels. The base level was 10 percent of the magnetic ballast shipments in 1997.

5.3.1.3 Market Incentive Impacts

As discussed in Market Weights (section 5.2.2) and in the Decreasing Shipments Scenarios above, the base case scenarios implicitly assumed that some magnetic ballast systems were being converted to higher efficiency ballast systems through early retrofit programs. Prior to 1996, electric utility demand-side management (DSM) programs provided rebates for ballast conversions. Although these rebates are being phased out under utility deregulation, other voluntary programs have begun to affect the market. Major programs are the Environmental Protection Agency (EPA) Green Lights (now Energy Star Buildings) program, the Federal Energy Management Program (FEMP) Procurement Challenge and Federal Relighting Initiative, DOE's Rebuild America program, and NEMA's Energy Cost Savings Council. Building codes being adopted by states to conform with the ASHRAE-IES 90.1-1989 building code under the Energy Policy Act of 1992 also affect ballast choices in new buildings.

To better estimate these impacts, we analyzed non-regulatory program and building code impacts on the ballast market. Lawrence Berkeley National Laboratory (LBNL) conducted a study[2] to estimate the number of fluorescent ballasts affected by DSM rebates from 1992 to 1997. Detailed analysis of data on spending amounts and units receiving rebates from several major utilities, accounting for up to 30 percent of the national total, was combined with EIA estimates of national DSM spending to produce estimates of ballasts rebated. Results indicated that the number of rebates and the percentage of the ballast market affected by rebates both declined since 1995. When the ASHRAE/IES code is revised (90.1-1999), the lower lighting power density limits will be an incentive for increasing use of electronic ballasts after 2005. DOE is preparing a new revision of the code for federal buildings that will also encourage the use of electronic ballasts. The EPA programs have resulted in a growing number of voluntary lighting upgrades that include electronic ballasts. The FEMP programs are expected to have modest but important impacts increasing the market share for electronic ballasts purchased for federal buildings.

More details on these shipments forecasts, as well as the impact of market incentive programs, are found in Appendix B.

5.3.2 Standards Scenarios

All of the scenarios assumed that users who would buy magnetic ballasts in the base case would purchase another ballast type in the standards case. In some scenarios, users would purchase the ballast type whose Ballast Efficacy Factor (BEF) just met the standard. In other scenarios, a fraction of the users would respond to the standard by purchasing ballasts even more efficient than required by the standard. In some cases, those more efficient ballasts would be part of a ballast/lamp system that would involve a shift to a different lamp type.

For all scenarios, the effective date was January, 2003. For some scenarios, the effective date applied to one portion of the ballast market, and a delay was assumed for the other market segment.

Each scenario was modeled using three different fuel price forecasts from the AEO 99: the Reference Case forecast, the High Economic Growth forecast, and the Low Economic Growth forecast. Savings from the Reference Case forecast were in between the higher savings under the High forecast and the lower savings under the Low forecast, because these scenarios assumed higher and lower energy prices respectively, for the base case. See section 5.3.4 below for the results of these three forecasts.

[2] Busch, C., I. Turiel, B.A. Atkinson, J.E. McMahon, J.H. Eto. 1999. "DSM Rebates for Electronic Ballasts: National Estimates (1992-1997) and Assessment of Market Impact." Lawrence Berkeley National Laboratory.

5.3.3. Electronic Ballast Trial Standards Scenarios

Scenario 1. This scenario assumed that 100 percent of magnetic ballasts were converted to electronic T12 ballasts. This scenario was intended to model the impacts of minimal compliance with the standard.

Scenario 2. This scenario assumed that all magnetic ballasts were converted to electronic ballasts, with 5 percent becoming T12 ballasts and 95 percent becoming T8 ballasts. This scenario was intended to model the likely market behavior under a standard, based on historical shipment data showing that nearly all (95 percent) of electronic ballasts purchased from 1993 - 1997 were T8 ballasts.

This Scenario, as well as Scenarios 3 and 4 below that also contained some usage of T8 systems, assumed that the T8 lamps were driven by electronic *rapid* start (ERS) ballasts. In the current market, about 25 percent of T8 electronic ballasts are rapid start, with the remaining 75 percent being *instant* start[4]. Despite the higher market share of instant start ballasts, this analysis focused on rapid start ballasts; a standard level requiring electronic instant start ballasts would not be appropriate since these ballasts are not used in applications where lamps are switched frequently (such as with occupancy sensors) as the instant start mode shortens lamp life. The assumption of rapid start ballasts therefore gave somewhat conservative results, as the savings from T8 instant start ballasts would be higher than those from T8 rapid start ballasts.

Scenario 3. This scenario assumed that the new/renovation luminaire market segment converted all ballasts to electronic, with 100 percent becoming T8 ballasts, starting on the effective date for standards. This segment was assumed to make up 70 percent of the total ballast market. The replacement market had a delay period of five years, after which magnetic ballasts were converted to electronic ballasts, with 5 percent becoming T12 ballasts and 95 percent becoming T8 ballasts. The replacement segment was 30 percent of the total market (see sections 5.2.2 and 5.3.1 above for descriptions of these market segments). This scenario reflected the differing impacts of standards on the two market segments, allowing an adjustment period for the replacement market users in existing buildings to prepare for the new ballast type. Adding individual electronic ballasts to a space with magnetically-ballasted fixtures could complicate maintenance and inventory, and cause a variation in light quality because of different lamp colors.

Scenario 4. This scenario made identical assumptions to Scenario 3, except that the delay period for the replacement market was two years.

Each of these four scenario forecasts above was compared with those of the two base cases. As described above in section 5.3.1, magnetic shipments decreased more rapidly in the base case called “Decreasing Shipments to 2015.” Comparisons of the four electronic ballast standards forecasts above with the 2015 base case are referred to as Scenario 1A, Scenario 2A, Scenario 3A, and Scenario 4A. Forecasts runs using the “Decreasing Shipments to 2027" base case are called Scenario 1B, Scenario 2B, Scenario 3B, and Scenario 4B.

5.3.4 Cathode Cutout Trial Standards Scenarios

Scenario 5. This scenario assumed that 100 percent of magnetic ballasts were converted to cathode cutout ballasts. The exception is the F96T12 ballast lamp-ballast combination, for which there is no cathode cutout option. These ballasts were assumed to remain magnetic under standards. This scenario modeled the impacts of minimal compliance with the standard.

Scenario 6. This scenario assumed that 30 percent of ballasts were converted to cathode cutout ballasts, and 70 percent were converted to electronic ballasts, with 5 percent becoming T12 electronic ballasts and 95 percent becoming T8 electronic ballasts. The assumption was that some users would respond to a cathode cutout standard by selecting more efficient and cost-effective electronic ballasts, which would also comply with the standard.

Cathode cutout forecasts run with the Decreasing Shipments to 2015 base case are denoted as 5A and 6A. Cathode cutout forecasts run with the Decreasing Shipments to 2027 base case are called 5B and 6B.

Table 5.4 summarizes the assumptions for the six scenarios run under the two base cases.

Table 5.4. Ballast Scenario Assumptions

<table>
<tr><th rowspan="2">Scenario</th><th rowspan="2">Ballast Type</th><th colspan="4">Electronic Ballast Percent</th><th colspan="2">Market Segment</th><th rowspan="2">Delay Period for Repl. Mkt. (years)</th><th rowspan="2">Base Case Decreasing Shipments Year</th></tr>
<tr><th colspan="2">T12</th><th colspan="2">T8</th><th>New</th><th>Repl</th></tr>
<tr><td>1A</td><td>ERS</td><td colspan="2">100</td><td colspan="2">0</td><td>NA</td><td>NA</td><td>0</td><td>2015</td></tr>
<tr><td>1B</td><td>ERS</td><td colspan="2">100</td><td colspan="2">0</td><td>NA</td><td>NA</td><td>0</td><td>2027</td></tr>
<tr><td>2A</td><td>ERS</td><td colspan="2">5</td><td colspan="2">95</td><td>NA</td><td>NA</td><td>0</td><td>2015</td></tr>
<tr><td>2B</td><td>ERS</td><td colspan="2">5</td><td colspan="2">95</td><td>NA</td><td>NA</td><td>0</td><td>2027</td></tr>
<tr><td rowspan="2">3A</td><td rowspan="2">ERS</td><td>New</td><td>Repl</td><td>New</td><td>Repl</td><td rowspan="2">70</td><td rowspan="2">30</td><td rowspan="2">5</td><td rowspan="2">2015</td></tr>
<tr><td>0</td><td>5</td><td>100</td><td>95</td></tr>
<tr><td rowspan="2">3B</td><td rowspan="2">ERS</td><td>New</td><td>Repl</td><td>New</td><td>Repl</td><td rowspan="2">70</td><td rowspan="2">30</td><td rowspan="2">5</td><td rowspan="2">2027</td></tr>
<tr><td>0</td><td>5</td><td>100</td><td>95</td></tr>
<tr><td rowspan="2">4A</td><td rowspan="2">ERS</td><td>New</td><td>Repl</td><td>New</td><td>Repl</td><td rowspan="2">70</td><td rowspan="2">30</td><td rowspan="2">2</td><td rowspan="2">2015</td></tr>
<tr><td>0</td><td>5</td><td>100</td><td>95</td></tr>
<tr><td>4B</td><td>CC</td><td colspan="2">0</td><td colspan="2">0</td><td>NA</td><td>NA</td><td>0</td><td>2015</td></tr>
<tr><td>5B</td><td>CC</td><td colspan="2">0</td><td colspan="2">0</td><td>NA</td><td>NA</td><td>0</td><td>2027</td></tr>
<tr><td>6A</td><td>CC</td><td colspan="2">3.5</td><td colspan="2">66.5</td><td>NA</td><td>NA</td><td>0</td><td>2015</td></tr>
<tr><td>6B</td><td>CC</td><td colspan="2">3.5</td><td colspan="2">66.5</td><td>NA</td><td>NA</td><td>0</td><td>2027</td></tr>
</table>

For Scenarios 6A and 6B, cathode cutout ballasts represented 30 percent of the magnetic ballast conversions. Of the 70 percent that convert to electronic, 5 percent were T12 (3.5 percent of the total) and 95 percent were T8 (66.5 percent of the total).

5.3.5 Alternative Electricity Price Projections

The EIA prepares annual forecasts of electricity prices to the year 2020. The projection thought to be the most likely given current economic trends was the Reference Case forecast. The High Economic Growth forecast assumes higher electricity rates in the future because of a high rate of economic growth. The Low Economic Growth forecast assumes lower electricity rates in the future in response to economic growth. The Gas Research Institute's 1999 electricity price projection was also considered, but because it falls within the range of the AEO High and Low cases, we decided not to use it. However, it is available as an alternative projection in the NES model.

5.3.6 Results

The results presented used the three AEO electricity price forecasts. The different price forecasts affected only the Total Benefit (energy cost savings) and NPV; the energy savings and equipment costs were the same as those in the Reference Case forecast.

Tables 5.5 through 5.10 show the energy savings, energy savings with lighting/HVAC impacts, energy cost savings, equipment costs, and NPV for the six scenarios and the two shipments base cases. These results were totaled for the four lamp-ballast combinations; tables in Appendix B present the detailed results by lamp-ballast combination.

Table 5.5 National Energy Savings Results, AEO Reference Case, Electronic Standards

Electronic Standards								
For Units Sold from 2003 to 2030 **Discounted at 7% to 1997 (in billion 1997 $)**								
SCENARIO	***Scen 1A T12 Decr2015***	***Scen 1B T12 Decr2027***	***Scen 2A T12/T8 Decr2015***	***Scen 2B T12/T8 Decr2027***	***Scen 3A Decr2015***	***Scen 3B Decr2027***	***Scen 4A Decr2015***	***Scen 4B Decr2027***
Total Quads Saved	1.01	1.79	1.66	2.93	1.43	2.66	1.57	2.84
Total Quads Saved w/HVAC*	1.08	1.90	1.76	3.12	1.52	2.82	1.67	3.02
Total Exajoules Saved	1.07	1.89	1.75	3.09	1.51	2.80	1.65	3.00
Total Exajoules Saved w/ HVAC*	1.14	2.01	1.86	3.29	1.60	2.98	1.76	3.18
Total Benefit	1.97	3.13	3.22	5.13	2.68	4.46	2.98	4.85
Total Equipment Cost	1.01	1.62	0.80	1.27	0.64	1.08	0.72	1.18
Net Present Value	0.96	1.51	2.43	3.86	2.03	3.38	2.26	3.68
*For energy savings only; Total Benefit and Net Present Value do not include HVAC savings.								

Table 5.6 National Energy Savings Results, AEO Reference Case. CC Standards

Cathode Cutout Standards				
For Units Sold from 2003 to 2030 Discounted at 7% to 1997 (in billion 1997 $)				
SCENARIO	*Scen 5A 100% CC Decr2015*	*Scen 5B 100% CC Decr2027*	*Scen 6A 30% CC Decr2015*	*Scen 6B 30% CC Decr2027*
Total Quads Saved	0.48	0.85	1.12	1.98
Total Quads Saved w/HVAC*	0.51	0.91	1.19	2.11
Total Exajoules Saved	0.51	0.90	1.18	2.09
Total Exajoules Saved w/HVAC*	0.54	0.96	1.26	2.22
Total Benefits	0.94	1.49	2.18	3.47
Total Equipment Cost	0.78	1.26	0.58	0.93
Net Present Value	0.16	0.23	1.60	2.54

Table 5.7 National Energy Savings Results, AEO High Case, Electronic Standards

Electronic Standards								
For Units Sold from 2003 to 2030 Discounted at 7% to 1997 (in billion 1997 $)								
SCENARIO	***Scen 1A T12 Decr2015***	***Scen 1B T12 Decr2027***	***Scen 2A T12/T8 Decr2015***	***Scen 2B T12/T8 Decr2027***	***Scen 3A Decr2015***	***Scen 3B Decr2027***	***Scen 4A Decr2015***	***Scen 4B Decr2027***
Total Quads Saved	1.01	1.79	1.66	2.93	1.43	2.66	1.57	2.84
Total Quads Saved w/HVAC*	1.08	1.90	1.76	3.12	1.52	2.82	1.67	3.02
Total Exajoules Saved	1.07	1.89	1.75	3.09	1.51	2.80	1.65	3.00
Total Exajoules Saved w/ HVAC*	1.14	2.01	1.86	3.29	1.60	2.98	1.76	3.18
Total Benefit	2.11	3.37	3.46	5.53	2.88	4.81	3.30	5.24
Total Equipment Cost	1.01	1.62	0.80	1.27	0.64	1.08	0.72	1.18
Net Present Value	1.10	1.75	2.66	4.25	2.23	3.73	2.48	4.06

*For energy savings only;
Total Benefit and Net Present Value do not include HVAC savings.

Table 5.8 National Energy Savings Results, AEO High Case. CC Standards

Cathode Cutout Standards				
For Units Sold from 2003 to 2030 Discounted at 7% to 1997 (in billion 1997 $)				
SCENARIO	*Scen 5A 100% CC Decr2015*	*Scen 5B 100% CC Decr2027*	*Scen 6A 30% CC Decr2015*	*Scen 6B 30% CC Decr2027*
Total Quads Saved	0.48	0.85	1.12	1.98
Total Quads Saved w/HVAC*	0.51	0.91	1.19	2.11
Total Exajoules Saved	0.51	0.90	1.18	2.09
Total Exajoules Saved w/HVAC*	0.54	0.96	1.26	2.22
Total Benefits	1.00	1.60	2.34	3.74
Total Equipment Cost	0.78	1.26	0.58	0.93
Net Present Value	0.22	0.35	1.76	2.81

Table 5.9 National Energy Savings Results, AEO Low Case, Electronic Standards

Electronic Standards								
For Units Sold from 2003 to 2030 Discounted at 7% to 1997 (in billion 1997 $)								
SCENARIO	***Scen 1A T12 Decr2015***	***Scen 1B T12 Decr2027***	***Scen 2A T12/T8 Decr2015***	***Scen 2B T12/T8 Decr2027***	***Scen 3A Decr2015***	***Scen 3B Decr2027***	***Scen 4A Decr2015***	***Scen 4B Decr2027***
Total Quads Saved	1.01	1.79	1.66	2.93	1.43	2.66	1.57	2.84
Total Quads Saved w/HVAC*	1.08	1.90	1.76	3.12	1.52	2.82	1.67	3.02
Total Exajoules Saved	1.07	1.89	1.75	3.09	1.51	2.80	1.65	3.00
Total Exajoules Saved w/ HVAC*	1.14	2.01	1.86	3.29	1.60	2.98	1.76	3.18
Total Benefit	1.79	2.84	2.94	4.65	2.43	4.03	2.71	4.39
Total Equipment Cost	1.01	1.62	0.80	1.27	0.64	1.08	0.72	1.18
Net Present Value	0.78	1.22	2.14	3.38	1.79	2.95	1.99	3.22

*For energy savings only;
Total Benefit and Net Present Value do not include HVAC savings.

Table 5.10 National Energy Savings Results, AEO Low Case. CC Standards

Cathode Cutout Standards				
For Units Sold from 2003 to 2030 Discounted at 7% to 1997 (in billion 1997 $)				
SCENARIO	*Scen 5A 100% CC Decr2015*	*Scen 5B 100% CC Decr2027*	*Scen 6A 30% CC Decr2015*	*Scen 6B 30% CC Decr2027*
Total Quads Saved	0.48	0.85	1.12	1.98
Total Quads Saved w/HVAC*	0.51	0.91	1.19	2.11
Total Exajoules Saved	0.51	0.90	1.18	2.09
Total Exajoules Saved w/HVAC*	0.54	0.96	1.26	2.22
Total Benefits	0.85	1.35	1.99	3.15
Total Equipment Cost	0.78	1.26	0.58	0.93
Net Present Value	0.07	0.09	1.41	2.22

Energy Savings

Energy savings from the electronic ballast trial standards scenarios with the AEO Reference Case ranged from about 1 Quad (1.1 exajoules) to 2.9 Quads (3.1 exajoules) of source energy. With the slower decreasing shipments forecast (to 2027), energy savings increased by approximately 75 percent for Scenarios 1 and 2 and 80 to 85 percent for Scenarios 3 and 4 (with delay periods) over those with the faster decreasing shipments forecast (to 2015). Energy savings for Scenario 2 with T8 electronic ballasts were almost 65 percent those for Scenario 1 with T12 electronic ballasts. For Scenario 3, which may be compared with Scenario 2 because the percentage of T12 vs. T8 ballasts is nearly identical, the five-year delay period caused a savings reduction of around 10 to 15 percent. For Scenario 4, the two-year delay period resulted in a savings reduction of about 5 percent from Scenario 2.

For the cathode cutout trial standards scenarios with the AEO Reference Case, energy savings ranged from 0.5 to 2.0 Quads (0.5 to 2.1 exajoules). For both scenarios, the slower decreasing shipments forecast (to 2027) resulted in increased savings of about 75 percent compared with those from the faster decreasing shipments (to 2015). The Scenario 6 savings from partial conversion to electronic ballasts were approximately 2.3 times higher than those of Scenario 5.

Additional HVAC savings increased the total energy savings by 6.25 percent.

Energy Consumption

As explained below, we estimated that base case cumulative fluorescent lighting energy consumption for the period from 2003 to 2030 was approximately 83.3 Quads (87.8 EJ) for the Decreasing Shipments to 2015 base case and 90.6 Quads (95.6 EJ) for the Decreasing Shipments to 2027 base case. The savings from standards ranged from 1 percent to 3 percent of the total estimated consumption for the period.

Since the NES model calculates energy savings rather than energy consumption, we performed a separate calculation to estimate fluorescent lighting energy consumption for the period 2003 to 2030. We estimated consumption separately for each "Decreasing Shipments" base case. The first step was to estimate the number of ballasts in existing buildings. We based this on the E-Source Strategic memo "How Far Have We Come? Remaining Opportunities for Upgrading Fluorescent Ballasts and Lamps,"[5] which estimated 657 million ballasts for the year 1996 (722 million ballasts minus 9 percent or 65 million low power factor ballasts exempted from the standards). This estimate was based on a simple vintaging model applied to estimated sales of ballast shipments from 1971 through 1996. We subtracted another 4 percent (26 million) as an estimate of exempted types other than low power factor ballasts. Since the E-Source calculations assumed a ballast service lifetime of 12.5 years and the ballast lifetime we would have assumed was 13.9 years (50,000 hour ballast life divided by 3600 annual lighting hours for all ballasts), we adjusted the number of ballasts by the ratio of the two lifetimes (13.9 / 12.5), yielding about 700 million ballasts. For the 1997 existing stock, 80 percent was assumed to be magnetic ballasts, derived from E-Source percentages for energy-efficient and standard magnetic ballasts.

To estimate the magnetic ballasts in existing buildings, we used a turnover rate of 6.8 percent per year (3400 annual lighting hours divided by 50,000 hour ballast life for magnetic ballasts, as discussed in Chapter 3). These magnetic ballasts were assumed to be removed from the magnetic ballast stock each year, and the annual magnetic ballast shipments projected by the NES model were added to the magnetic ballast stock (separately for each scenario). The total ballast stock was assumed to grow by 1 percent per year, based on the floor space projections shown in Table B.34 in Appendix B. The number of electronic ballasts was calculated by subtracting the magnetic ballasts from the total ballasts. For the 2015 scenario, the stock became 50 percent magnetic by 2010, and was 14 percent magnetic by 2030. For the 2027 scenario, the stock was 50 percent magnetic by 2013 and 20 percent magnetic by 2030.

Energy consumption was calculated by multiplying the annual ballast shipments times a weighted unit energy consumption (UEC) per ballast. The NES model calculates the UEC for each each of the four major lamp/ballast combinations in the NES model (see Appendix B). The percentage of total shipments represented by each combination was estimated from the NES model shipments data, and the percentage magnetic of each combination was derived from the NEMA data in Table B.1 above. We used these percentages to weight the four UECs, performing separate calculations for magnetic and electronic ballasts. The results for the four lamp/ballast combinations were summed for an annual consumption in 1997 for both scenarios of 285 Twh or 3.13 Quads (using the site to source energy conversion factor for 1997 from Table 5.3). For the years 2003 to 2030, a similar procedure was followed, multiplying each year's shipments by the unit energy consumption. For the Decreasing Shipments to 2015 scenario, the result was 8325 Twh or 83.3 source Quads, using a heat rate of 10,000 Btu/kWh (the average for the period using AEO99 projections shown in Table 5.3). For the Decreasing Shipments to 2027 scenario, the result was 9061 Twh or 90.6 source Quads.

Net Present Value (NPV)

The NPV is the difference between fuel cost savings and equipment costs. Fuel cost savings are calculated by the NES model using annual site energy savings multiplied by each year's projected marginal electricity rate for the appropriate sector. Ballast and lamp equipment costs are calculated from the model inputs (see Appendix A and Appendix B). Both fuel cost savings and equipment costs are discounted to the year 1997 in $1997. Note that HVAC energy cost savings are not included in the NPV calculations.

The NPV for the electronic ballast trial standards scenarios ranged from about 1 billion to 3.9 billion dollars. For all the scenarios, NPV increased by almost 60 to 70 percent when the slower decreasing shipments forecast to 2027 was used. NPVs for Scenario 2 with T8 electronic ballasts were about 2.5 times those for Scenario 1 with T12 electronic ballasts. For Scenario 3, the five-year delay period caused an NPV reduction of around 15 percent from Scenario 2. For Scenario 4, the two-year delay period resulted in an NPV reduction of about 5 percent from Scenario 2.

For the cathode cutout trial standard level scenarios, NPV ranged from 0.2 to 2.5 billion dollars. The slower decreasing shipments forecast (to 2027) increased the NPV for Scenario 5 compared with the faster decreasing shipments forecast (to 2015) by about 45 to 60 percent. For Scenario 6, the NPV was 10 to 11 times greater than that of Scenario 5.

5.4 NET NATIONAL EMPLOYMENT

Net national employment impacts from ballast standards were defined as net jobs created or eliminated in the general economy as a consequence of reduced spending by commercial and industrial sector businesses on electricity, increased spending on the purchase price of ballasts and reduced spending on new power plants by the utility industry (along with the indirect effects of these three factors). Figure 5.4 shows the estimated net national employment impact of four different electronic ballast standards scenarios that are described in the NES results section (5.3.6).

These results came from our use of an input/output model of the U.S. economy to estimate the effects of standards on different major sectors of the U.S. economy most relevant to buildings and their net impact on jobs. The model was developed by the DOE Office of Building Technologies and State Programs. ImBuild (which stands for Impact of Building Energy Efficiency Programs) was created by the Pacific Northwest National Laboratory as a special-purpose version of the IMPLAN national input-output model. This software, ImBuild, is a PC-based economic analysis system that characterizes the interconnections among 35 economic sectors as national input-output structural matrices. The model can be applied to future time periods. ImBuild output includes employment and wage income. In comparison with simple economic multiplier approaches, ImBuild allows for more complete and automated analysis of the economic impacts of energy-efficiency investments in buildings. The impacts of new ballast standards were estimated in the NES spreadsheet as energy savings (reduced electricity use), energy cost savings, and increased ballast purchase prices. These three impacts (see Figures 5.5 - 5.7 below) were output from NES and input to ImBuild. Direct employment impacts, which would occur at ballast manufacturing plants, are discussed in the Manufacturer Impact Analysis results section in Chapter 6. Additional details about the ImBuild model follow.

Energy-efficiency technology affects the U.S. economy primarily through three mechanisms. First, if the incremental costs of the new technology per installed unit are different from those of the conventional technology, changes in purchases will occur in the sectors involved in manufacturing, distribution, and installation for both technologies, which will change the overall mix of economic activity. Second, depending on how the efficiency investment is financed, it may “crowd out” other domestic savings, investments, and consumer spending, somewhat reducing overall economic activity. Third, energy expenditures will be reduced. On one hand, this reduction lowers final demand in the electric utility sector as well as in the trade and services sectors that provide maintenance, parts, and services for the utility sector. On the other hand, it increases net disposable business income and increases general business spending in all sectors.

In an input/output model, the level of employment in an economy is determined by the relationship of different sectors of the economy and the spending flows among them. Different sectors have different levels of labor intensity and so changes in the level of spending (e.g., such as via an efficiency standard) in one sector of the economy will affect flows in others, which affects the overall level of employment.

Jobs are created when the net change in spending flows into more job-intensive sectors relative to the base case; jobs are lost when the net change in spending flows into less job-intensive sectors relative to the base case. An energy-efficiency standard for ballasts would create such changes in the spending flows of the economy. Standards would reduce ballast operating costs, which would in turn increase the amount of disposable income to consumers. A standard might also increase purchase price (reducing disposable income to consumers) and increase the demand for capital in the ballast manufacturing industry.

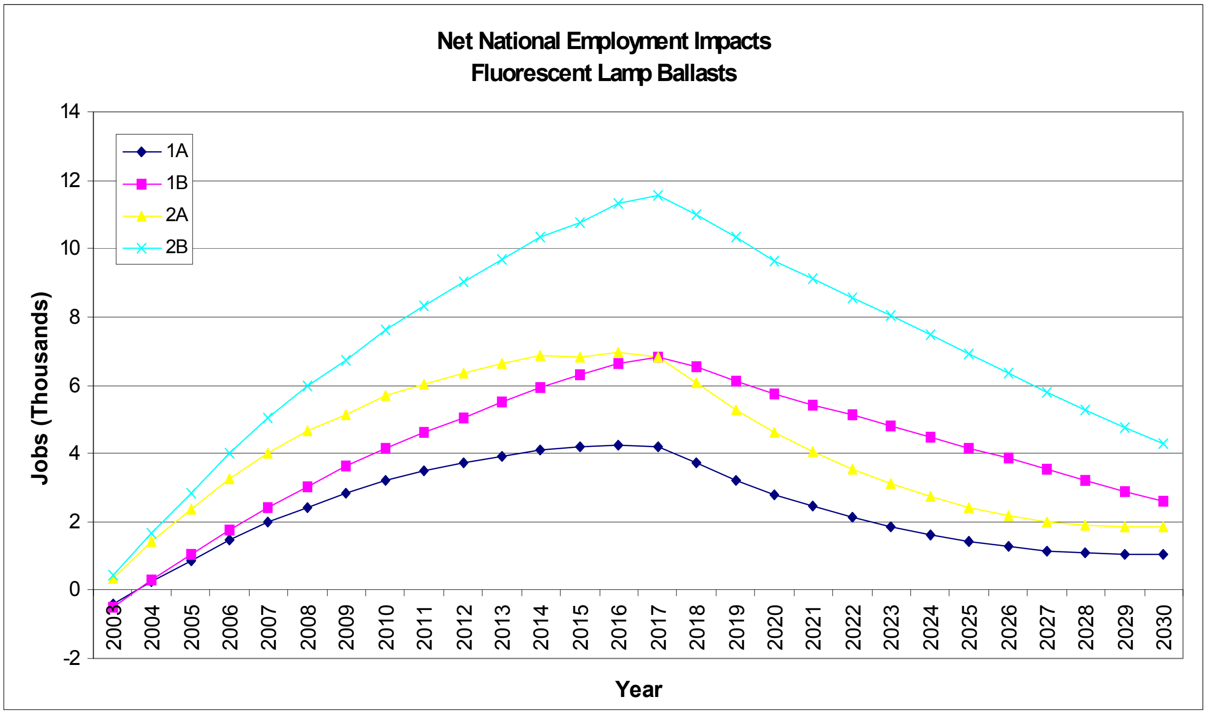

Figure 5.4. Net National Employment Impacts

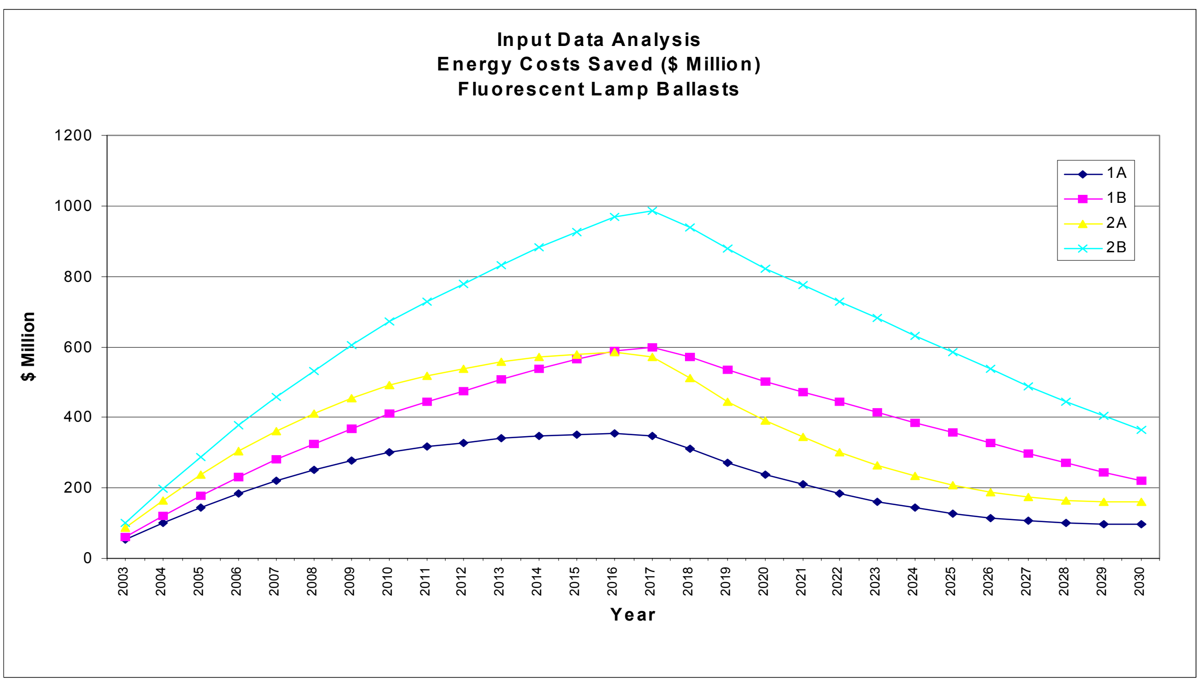

Figure 5.5. Input Data: Energy Costs Saved

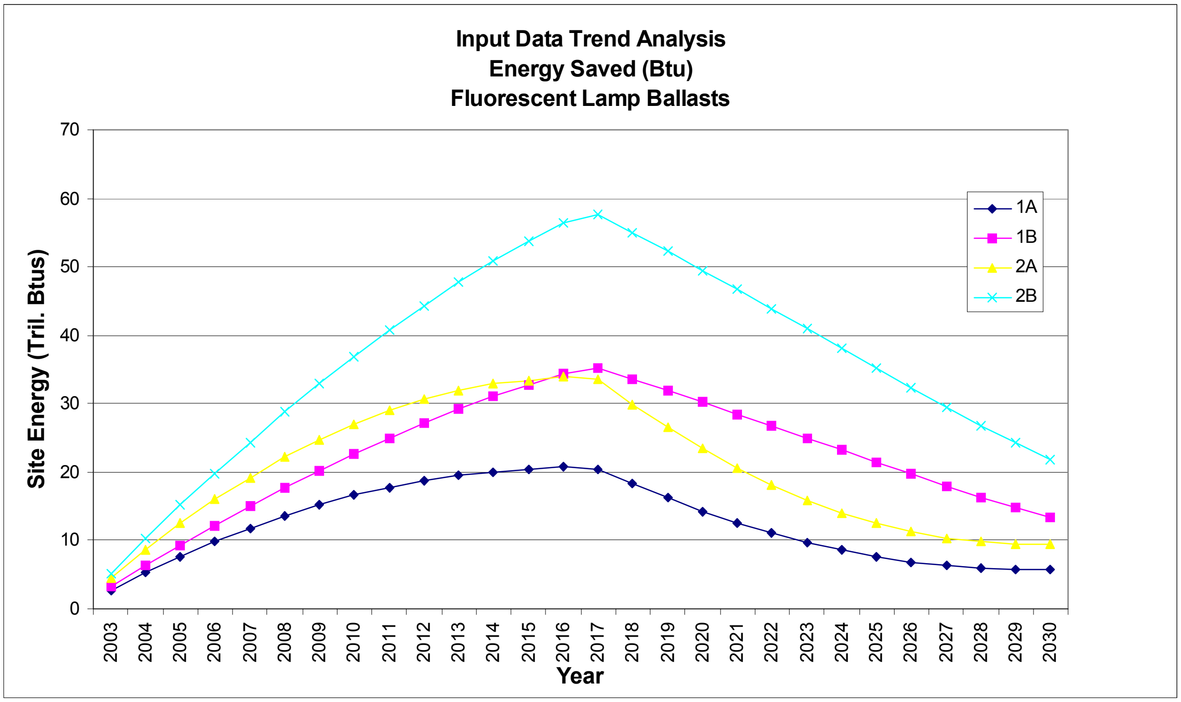

Figure 5.6. Input Data: Site Energy Saved

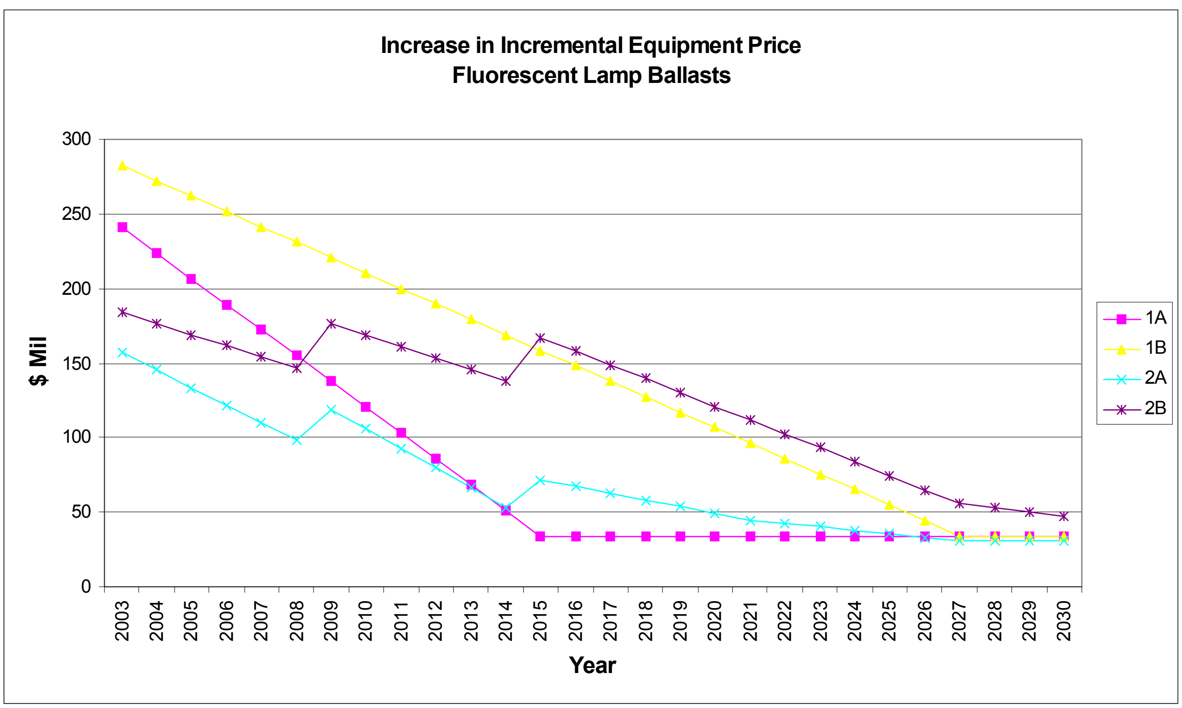

Figure 5.7. Input Data: Incremental Equipment Price Increase

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2. NEMA Comment #50, Attachment B, May 18th, 1999.

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4. Lighting Research Institute. 1995. Research for Lawrence Berkeley National Laboratory, Energy Analysis Program, by the Lighting Research Institute under LBNL Subcontract No. 4602810.

5. E-Source Inc. (Calwell, Dowers and Johnson). 1998. “How Far Have We Come? Remaining Opportunities for Upgrading Fluorescent Ballasts and Lamps,” SM-98-4, Boulder, CO, May 1998, Figure 7.